General Employee Radiological Training

(GERT)

TMS Course ESH738

Argonne National Laboratory

EQO

Training Group

August 2005

Course Objectives

Upon completion of this program, you will be able to discuss the Argonne National Laboratory Radiological Control Program in regards to radiological terminology, hazards and risks, controls and identification systems, and employee responsibilities. You will be able to:

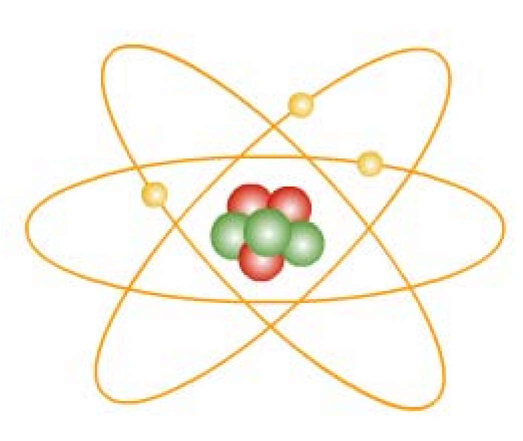
1. Identify fundamental radiological terms and concepts.
2. Identify natural and man-made sources of background radiation.
3. State the potential health effects of radiation exposure.
4. Compare risks due to occupational radiation exposure with other common health risks.
5. Identify the ALARA concept and practices.
6. State the methods used to recognize and control radiological hazards.
7. State management and individual responsibilities for the site radiological control program.

Introduction

General Employee Radiological Safety Training (GERT) is provided to all new employees and other site workers who may routinely enter Controlled Areas or encounter radiological barriers, postings or radioactive materials. Employee responsibilities for observing and obeying radiological control postings and procedures are emphasized throughout this training.

- It is important to note that general employees will probably not be exposed to radiation or radioactive materials.
- Additional training beyond GERT is required for employees who are identified as radiological workers.

1. Terms and Concepts



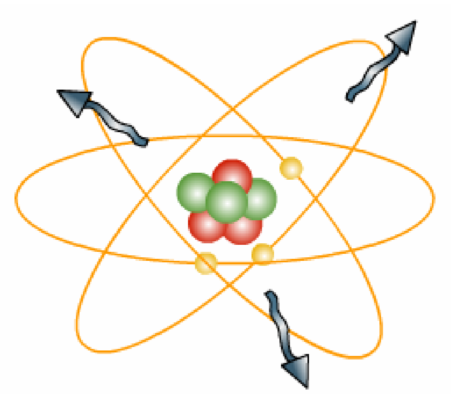
The **atom** is the smallest unit into which elements can be divided and still retain their unique chemical and physical properties.
The center of the atom is the **nucleus**. It is composed of **protons** and **neutrons**. **Electrons** orbit the nucleus like planets orbit the sun.

Atoms are composed of protons, neutrons, and electrons.

Proton
- Located within the nucleus
- Have a positive electrical charge
- The number of protons determines the element's identity (for example, 1 proton = hydrogen, 2 protons = helium, 6 protons = carbon)

Neutron
- Located within the nucleus
- Has no electrical charge
- The ratio of neutrons to protons influence nuclear stability (**stable** or **radioactive**)

Electron
- Located outside the nucleus
- Have a negative electrical charge
- The number of electrons determines the chemical properties of the atom

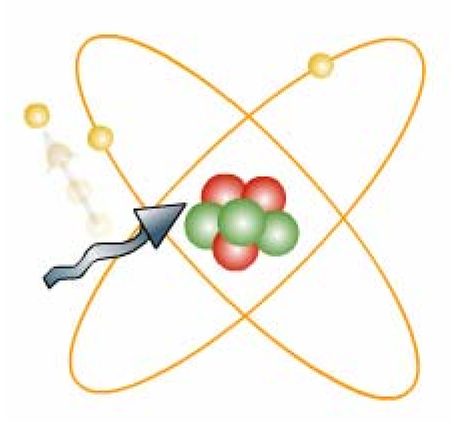


Atoms can emit **radiation**.

If there are too many or too few neutrons for a given number of protons, the resulting nucleus is considered **unstable**.

Over time, unstable atoms release excess energy in the form of particles or waves called ionizing **radiation**.

Definitions

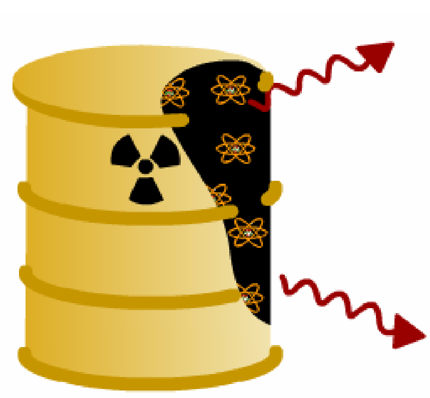


Ionization is the process by which electrons are removed or added to atoms.

Ionizing radiation is radiation with enough energy to remove an electron from an atom.

Radioactive material is any material containing atoms which release ionizing radiation. It can exist in various forms:

- Solid objects such as **activated** equipment
- Sealed radioactive sources
- Dispersible radioactive powder, liquid, gas, or vapor.



Radioactive materials containing unstable atoms

Even properly contained radioactive materials can emit radiation and be an external dose hazard. But properly contained radioactive material is not a contamination hazard.

Radioactive contamination is a radioactive material in an unwanted place. It is usually a liquid, powder, or dust.

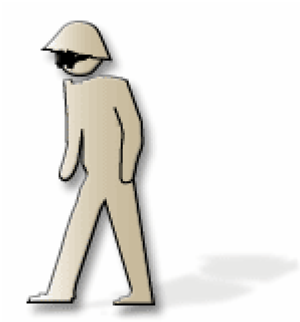
Exposure to radiation does not result in contamination.

Radiation is a type of **energy**; contamination is a **material**.

Radiation, radioactive material, and radioactive contamination can be compared to something familiar: **fire**.

The burning logs (material) give off heat, which is **radiation**.

Sparks, which are small pieces of burning material, can be spread to areas where they are not desired. This can be compared to **radioactive contamination**.

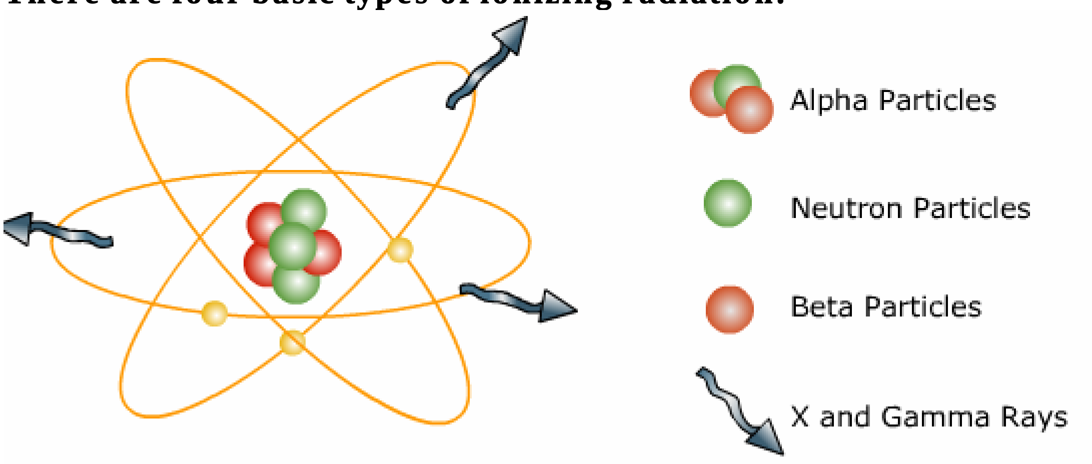


rem (**r**adiation **e**quivalent to **m**an) is the basic unit of radiation dose equivalent. It is usually expressed in a smaller unit called millirem (rem)

1000 mrem = 1 rem

The rem and mrem measure biological damage or health risk to humans.

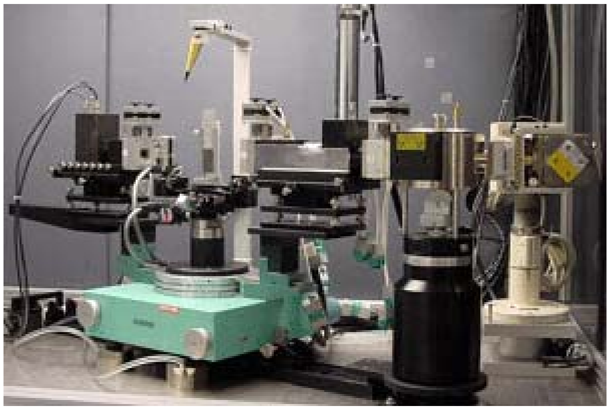
There are four basic types of ionizing radiation:



Radiation is released from the nucleus when unstable atoms change to a more stable condition.

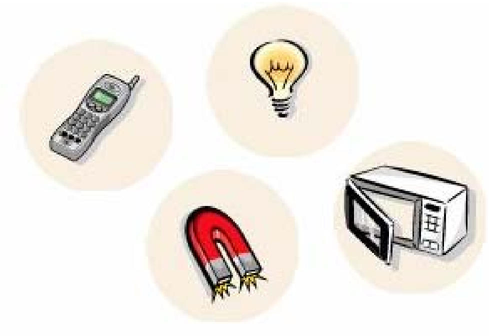
Ionizing radiation is also generated by radiation producing machines such as this analytical X-ray device.

Other radiation generating devices include particle accelerators and electron microscopes.



Ionizing radiation has sufficient energy to remove electrons from atoms.

Non-ionizing radiation does not have the amount of energy needed to remove electrons from the atom. Examples of non-ionizing radiation are:

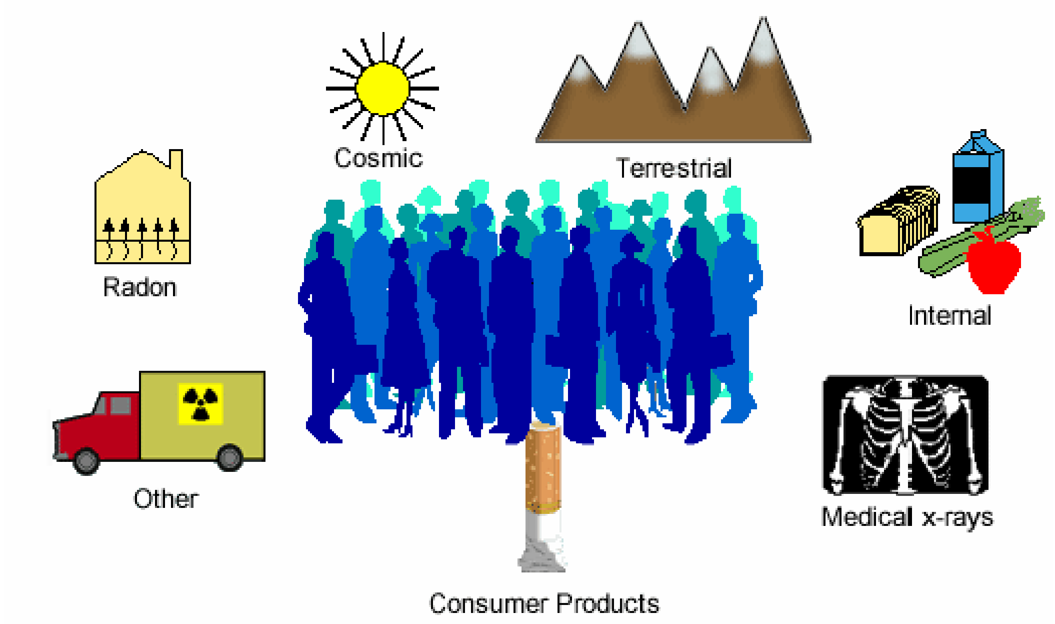


- Visible light
- Radio waves
- Microwaves
- Magnetic fields

2. Background Radiation

The average annual radiation dose to the general population is 360 mrem from natural background and man-made sources.

There are some of the sources of ionizing radiation to which we are all exposed:



Radon – Comes from the decay of radium, which is naturally present in soil. As a gas, radon can travel through the soil and enter buildings. Radon and its decay products emit alpha particles which are an internal hazard to the lung

Cosmic – Comes from the sun, stars and other sources in outer space. It consists of charged particle and gamma rays. The dose rate increases with altitude, since there is less atmosphere to shield this radiation

Terrestrial – Natural sources of radiation are present in soil, rocks, and building materials. These include potassium, radium, thorium, and uranium, which give us a continuous low level radiation exposure.

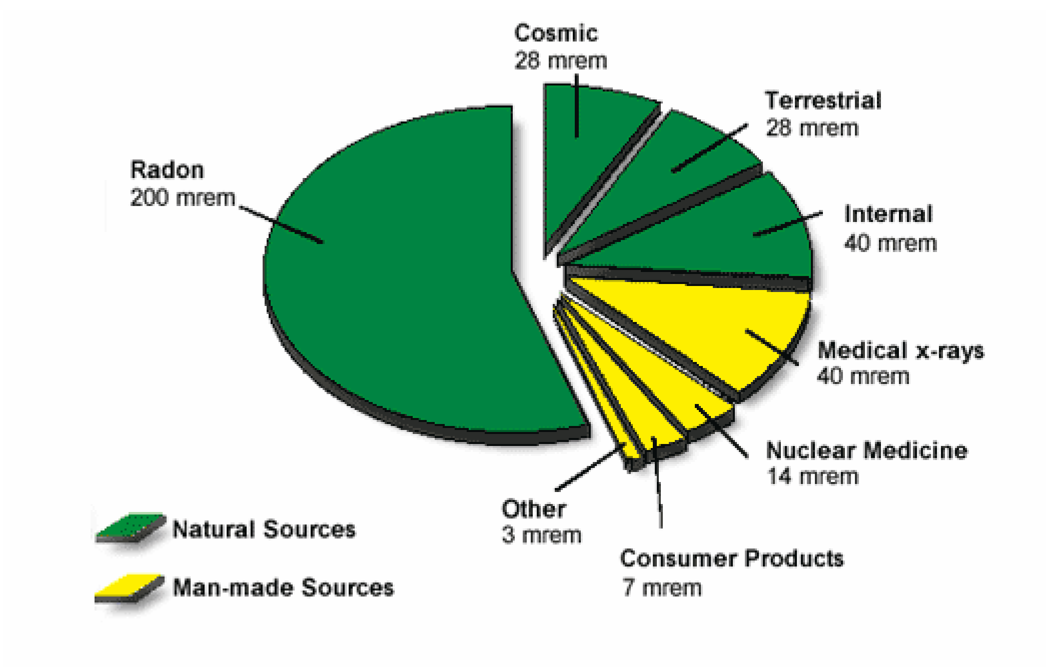
Internal – Food and water contain trace amounts of natural radioactive materials. Most of our internal dose is from radioactive form of potassium called K-40.

Medical X-rays – X-rays, CAT scan, and diagnostic and therapeutic uses of radioactive sources contribute the largest dose from man-made sources. Common medical sources include gallium-67, technetium-99m, thallium-201, and iodine-123,125,131.

Consumer Products – A small amount of radiation comes from consumer products such as old vacuum tube televisions, radium dial clocks and watches, smoke detectors and some ceramics. Smokers get a significant radiation dose to the lungs from polonium isotopes in tobacco leaf.

Other – Other man-made radiation sources include residual fallout from 1950's and 60's atmospheric nuclear weapons tests. Industrial uses include x-rays for baggage inspections and transportation of radioactive materials.

Background Radiation – Pie Chart



Radon is the single largest source of radiation to the general population.

3. Health Risks

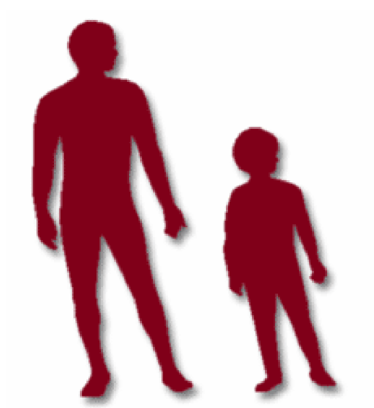
Potential Health Risks -

Our knowledge of radiation health effects is mainly from cases where high doses of radiation were received over short periods of time.

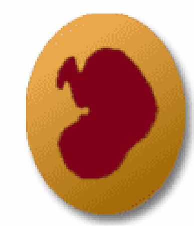
However, workers at radiological facilities who receive any radiation tend to receive small doses over long time periods.

These are called chronic radiation doses. Persons who receive chronic radiation doses may increase their risk of cancer. The probability of cancer due to occupational exposure is very small compared to the natural cancer death rate of 20%.

Radiation induced genetic disorders that are passed on to future generations are called **heritable effects**. These have been measured in plants and animals, but have not been observed in humans. We assume that heritable effects can occur in humans, but the probability is low compared to the normal rate of genetic disorders.



Prenatal radiation health effects have been observed in humans and animals exposed to high radiation doses while in the womb. These include:



- lower birth weight
- increased rate of mental retardation
- stunted physical growth
- reduced IQ

The effects have only been seen when fetal dose exceeded 15 rem.

Another concern is that prenatal radiation exposure may increase the risk of a future cancer such as leukemia.

DOE and ANL want to minimize radiation exposure to fetus/embryo. A pregnant worker who may receive radiation exposure should declare her pregnancy in writing. Go to the Medical Department in Building 201 and fill out a Pregnancy Declaration (ANL-243) form.

Once the pregnancy is “declared”, a more restrictive radiation dose limit is applied.

ANL policy is to keep the fetal radiation dose as far below the 500 mrem limit as reasonably achievable.

A declared pregnant worker will be counseled by Health Physics. She may opt to have her work duties changed to reduce the risk of radiation exposure.

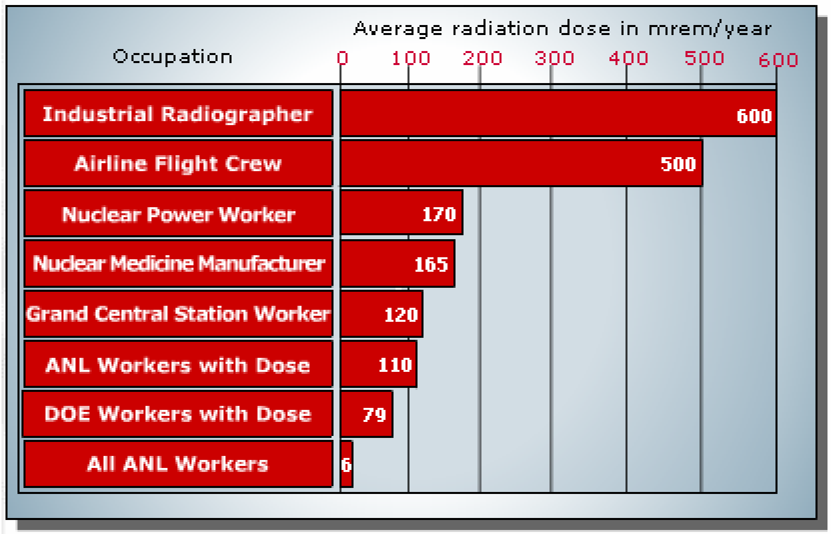
4. Risk Comparison

The radiation dose limit for workers at DOE facilities is 5000 mrem/year, while for site visitors and the general public the limit is 100 mrem/year.

Workers who expect to receive above 100 mrem/year are required to complete Radiological Worker Training. Persons like yourself are expected to receive less than 100 mrem/year due to occupational radiation exposure. This General Employee Radiation Training (GERT) safety orientation is sufficient for your current needs.

The health risks associated with occupation radiation exposures are very small and should be considered acceptable when compared to other risks we take daily. Let’s see how your expected radiation dose compares with that for other occupations.

Risk Comparison - Graph



Performing any of these activities exposes you to the same small risk.

Relative Risk of Dying
(Activities with one-in-a-million odds)

- Smoking 1.4 cigarettes (lung cancer)
- Eating 40 tablespoons of peanut butter
- Eating 100 charcoal broiled steaks
- 2 days in New York City (air pollution)
- Driving 40 miles in a car (accident)
- Flying 2,500 miles in a jet (accident)
- Canoeing for 6 miles
- Receiving 10 mrem radiation dose (cancer)

Loss of Average Life Expectancy

Cause	Days Lost
Being an unmarried male	3500
Smoking one pack/day	2250
Being an unmarried female	1600
Being a coal miner	1100
25% overweight	777
Alcohol abuse (U.S. average)	365
Being a construction worker	227
Driving a motor vehicle	207
All industries	60
Radiation dose of 100 mrem x 70 years	10
Drinking Coffee	6

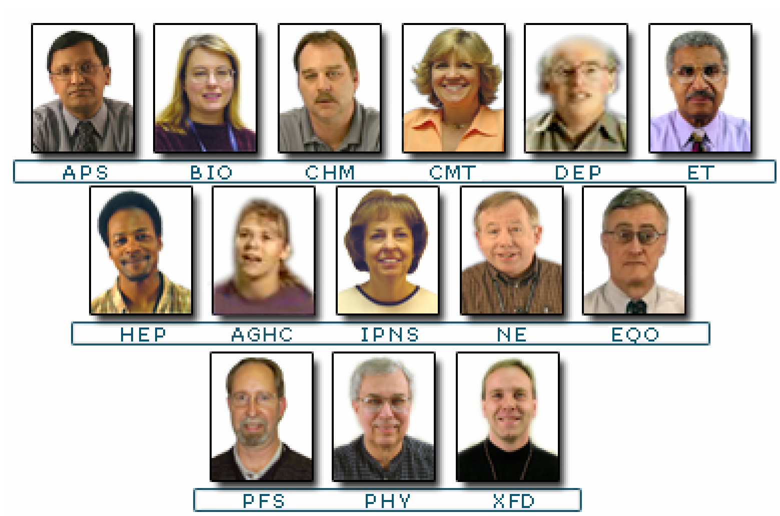
Another way to view risk is to measure the reduction in life span associated with various lifestyles.

5. ALARA

The **ALARA concept** is an integral part of all activities that use radioactive materials or radiation producing machines. It works to minimize radiation exposures to workers, the public, and the environment from site activities.

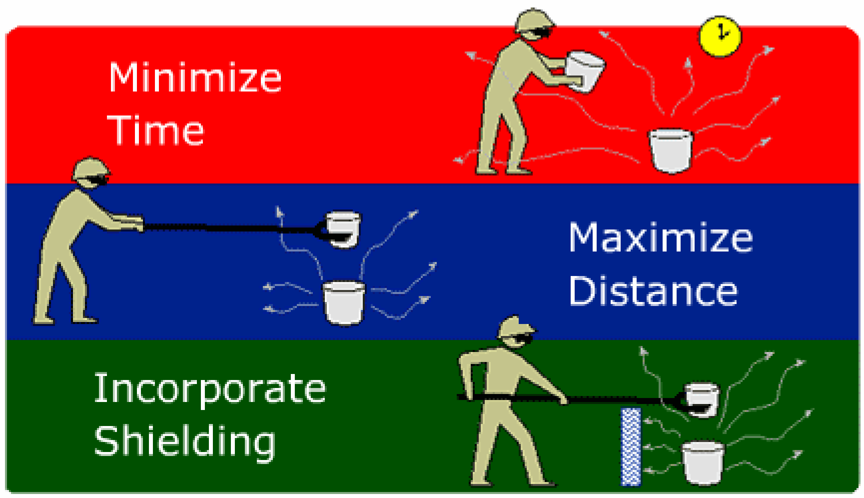
You are responsible for maintaining your radiation dose ALARA. But you do have help. The site-wide **ALARA coordinator**, Sam Baker*, provides technical support and assistance in the implementation of ALARA. He serves as the secretary of the site ALARA committee. He also issues quarterly reports which track and trend worker radiation doses.

* - As of August 2005



Division ALARA Coordinators monitor the ALARA program within their divisions and serve on the ALARA committee. Do you know which of these persons your division ALARA coordinator is?

To keep your radiation dose ALARA...



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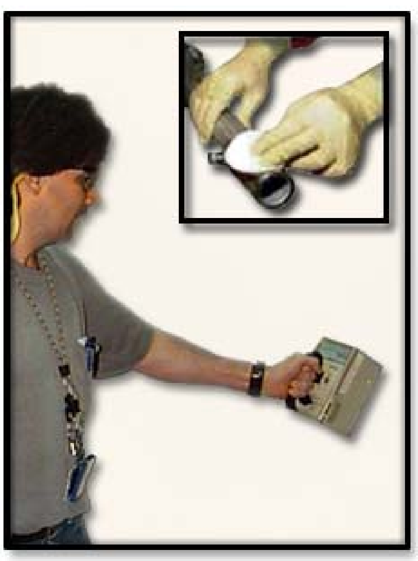
6. Radiological Controls



Human senses **cannot** detect radiation.

Since radiation cannot be detected with any of the sense, special detection devices must be used. The Health Physics technicians routinely measure radiation and contamination levels in suspect areas of the site.

If radiological conditions were found, they will be clearly identified with **radiological controls** such as postings, labels, or tags.

Signs that there could be a radiological hazard present:

- Yellow & magenta postings
- Radiological workers with personal protective clothing
- Flashing lights
- Yellow & magenta rope
- Audible alarms
- Magenta lab coats

Radiological Postings

Three General Warnings:
Grave Danger, **Danger**, and **Caution.**

Postings have magenta or black **trefoil** (propeller) symbol.

Radiological designation indicates the type and degree of hazard.

Always comply with **entry requirements.**

Dose rate, the date, and HP technician's initials are posted.

The posting to the left indicates a **minimal radiological hazard**. The space used for specific radiological designations is blank.

The dose rate inside a controlled area which has no radiological designation posted is less than 5 mR/hour at 30 cm (1 ft) from source.

If you see a sign like this, you must have the following to enter:

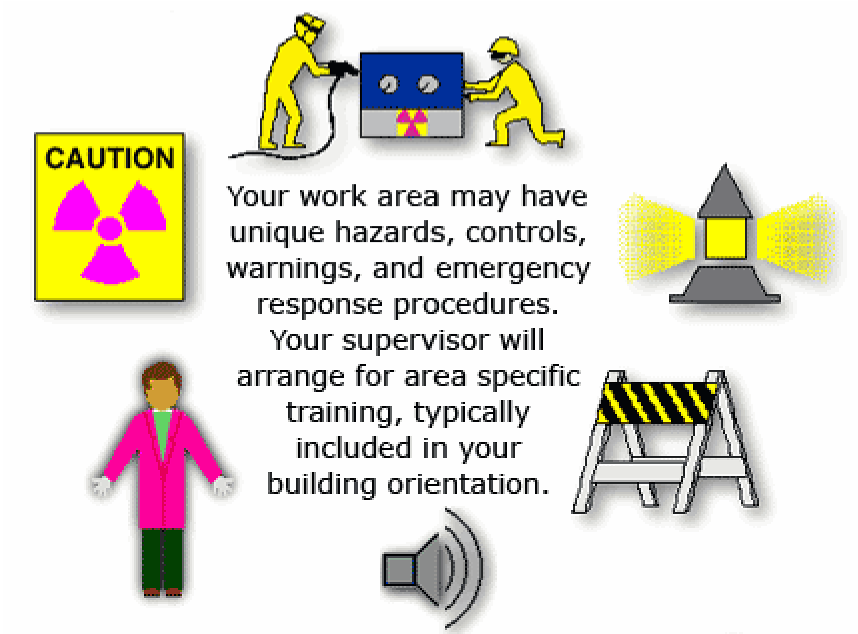
- **GERT qualification**
- **Authorization by area manager**

If there is any radiological designation, you must have a **qualified escort** and comply with all **entry requirements.**

Any worker that may receive a dose greater than 100 mrem/year is issued a radiation dosimeter badge, called a **TLD**.

Each year, 2500 ANL workers wear TLDs.

However, fewer than 250 receive a measurable dose.



7. Responsibilities

Management Responsibilities:

- Establish radiation exposure control levels and ALARA goals
- Solicit feedback from the workforce on improvements to the radiological control program
- Implement policies and procedures to maintain radiation exposures ALARA
- Hold workers accountable for radiological performance.

Your Responsibilities:

- Obey all signs and postings and comply with all radiological safety rules and procedures
- Do not enter any controlled area without authorization by the area manager
- If visiting a radiological area with a designated escort
    - Obey his or her instructions
    - Obtain and wear the required dosimeter(s)
    - Use ALARA techniques to minimize exposure
- Know how to contact Health Physics in your area and be alert for and respond to unusual radiological situations.

In some locations, you will be required to check for radioactive contamination by using a **Hand & Shoe monitor.** Follow the directions on the monitor.

If you get a positive reading:

- Stay in the area
- Call Health Physics
- Wait for help to arrive

Nuclear medicine procedures are a very common medical tool. Your doctor may recommend a test that requires you to drink or be injected with a radioactive substance. Your body will emit radiation during and a few days following the procedure.

If you work in a building that has posted radiological areas, and you received or plan to receive nuclear medicine, you are responsible to **notify the area Health Physics group**.

It is not necessary to notify HP if you get an X-ray, CAT scan, or MRI.